The Emerging SIBER Initiative of IMBER/IOGOOS: Biogeochemical Observing Programs and Modeling Needs in the Indian Ocean

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Sponsors:

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IMBER / IGBP (Integrated Marine Biogeochemistry and Ecosystem Research / International Geosphere-Biosphere Programme);
WIOMSA (Western Indian Ocean Marine Science Association);
CLIVAR / GOOS (An International Research Programme on Climate Variability and Predictability/The Global Ocean Observing System)
IOCCP (International Ocean Carbon Coordination Project)
CSIR (India's Council for Scientific and Industrial Research)
NOAA (U.S. National Oceanic and Atmospheric Administration)
NASA (U.S. National Aeronautics and Space Administration)

What is SIBER all about?

- **SIBER: Sustained Indian Ocean Biogeochemistry and Ecosystem Research**

- **SIBER initially emerged as a result of the potential opportunity to leverage the planned CLIVAR/GOOS Indian Ocean mooring array (IndOOS) and associated cruises, but has expanded to include the entire basin and all Indian Ocean GOOS components.**

- **The idea is to develop a new, basin-wide program in the IO focused on biogeochemical and ecological research, with the existing and planned observing systems and expeditions providing the observational foundation.**

- **It is also an opportunity to promote interdisciplinary, international collaboration and research in the Indian Ocean.**

- **It is time, the last major program was JGOFS over 10 years ago.**

- **But more to the point: The Indian Ocean is interesting and different. "It is one of the last great frontiers for ocean biogeochemical and ecological research"**

SIBER Conference, Goa October 3-6, 2006:

Workshop Accomplishments:

- More than 200 registered participants from many nations
- 44 invited speakers, > 50 poster presentations
- Reviewed the state of our knowledge of the biogeochemical and ecological dynamics of the IO and identified prominent gaps
- Generated roadmap for producing a science plan: Convene focused workshop in Goa in 2007
- Articles published in IMBER and *Eos* and an AGU monograph is in the works

SIBER Writing Workshop, Goa November 27-30, 2007:

Workshop Accomplishments:

- ~ 30 participants and 29 synthesis/overview presentations
- Synthesized information presented at the 2006 SIBER conference
- Considered related work, information and programs
- Developed the major research themes and regional foci of the SIBER Science Plan
- Developed the implementation components of the SIBER Science Plan
- *Generated significant amount of draft text for the SIBER Science Plan*
- Devised a strategy and timeline for producing the final document

Six Major Themes Identified:

(This is a very broad science plan that different countries can pick and choose from)

1. Boundary current dynamics,interactions and impacts on biogeochemistry and ecology

2. Dynamical variability of the equatorial zone, southern tropics and Indonesian Throughflow and their impacts on ecological processes and biogeochemical cycles

3. Physical, biogeochemical and ecological contrasts between the Arabian Sea and the Bay of Bengal

4. Controls and fate of phytoplankton and benthic production in the Indian Ocean

5. Climate and anthropogenic impacts on the Indian Ocean and its marginal seas

6. Role of higher trophic levels in ecological processes and biogeochemical cycles

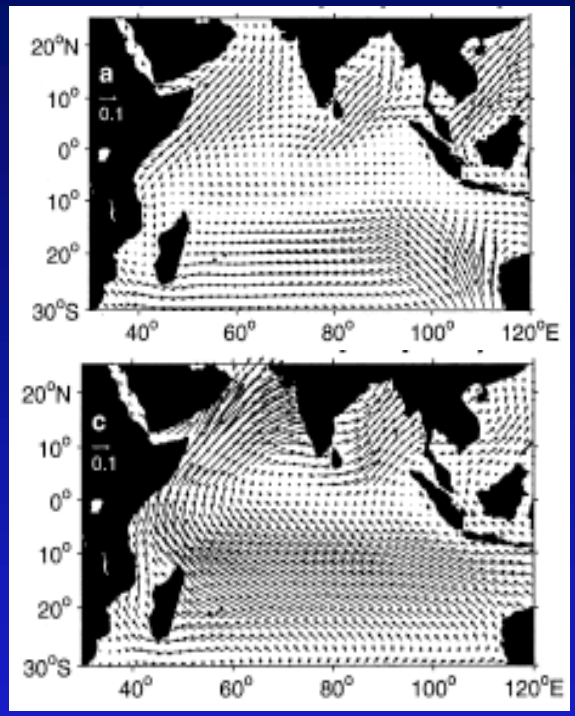
Six Major Themes Identified:

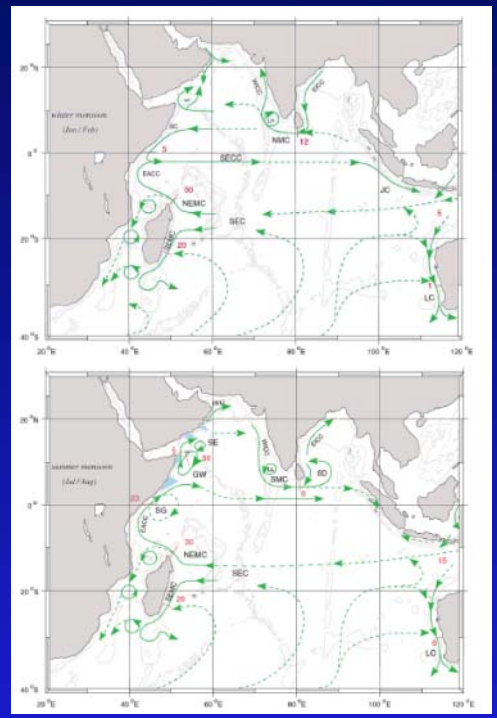
1. Boundary current dynamics, interactions and impacts on biogeochemistry and ecology

Winds | Circulation | Chlorophyll

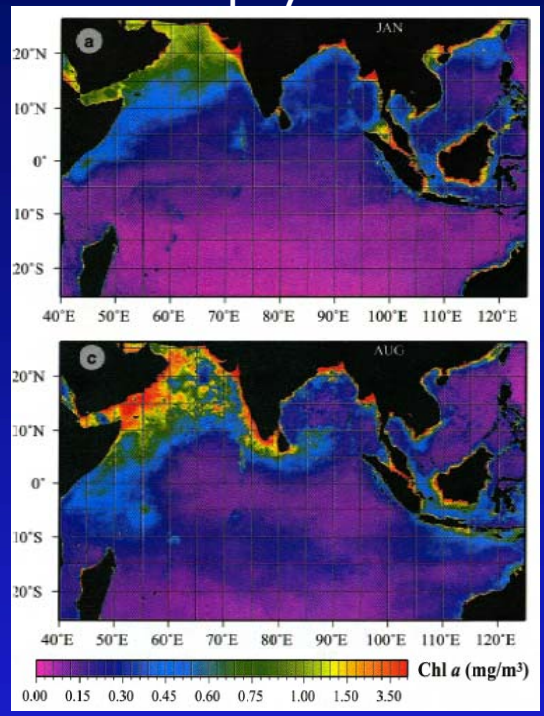
Jan/Feb →

Jul/Aug →





From Schott and McCreary, 2001



From Wiggert et al. 2006

The IO has strong boundary currents. Western boundary currents include the persistent Agulhas Current and the seasonally reversing Somali Current. Eastern boundary currents include the persistent Leeuwin Current and the seasonally reversing coastal currents off Indonesia and Bay of Bengal. These currents mediate transfer of global and regional forcing and strongly influence biogeochemical cycles and ecosystems.

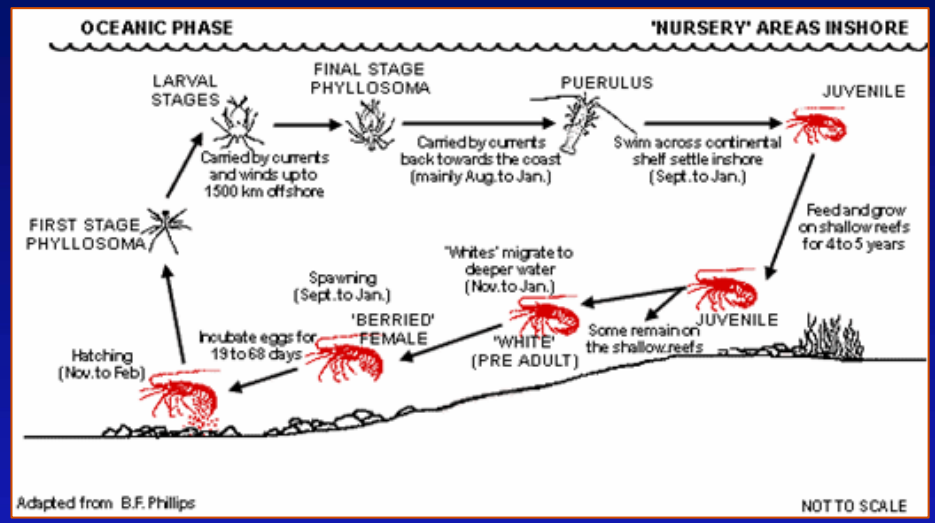
Observation and modeling needs:

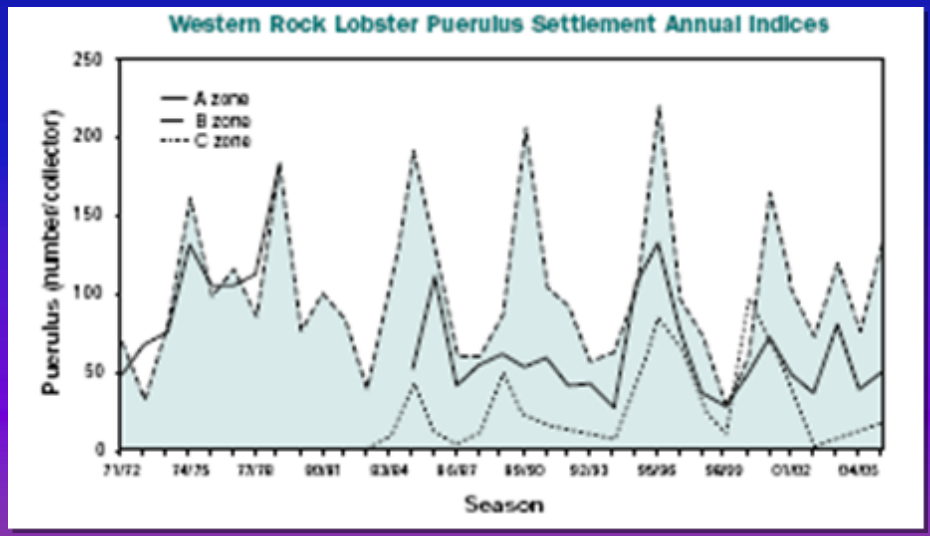
- Satellite observations (color, SST, and SSH) with better atmospheric corrections especially for the AS.
- Regional eddy resolving physical models (1/10 degree or less) with coupled biogeochemical models
- Coastal observatories with extended offshore capabilities (e.g., ships, gliders, moorings, ARGO floats).

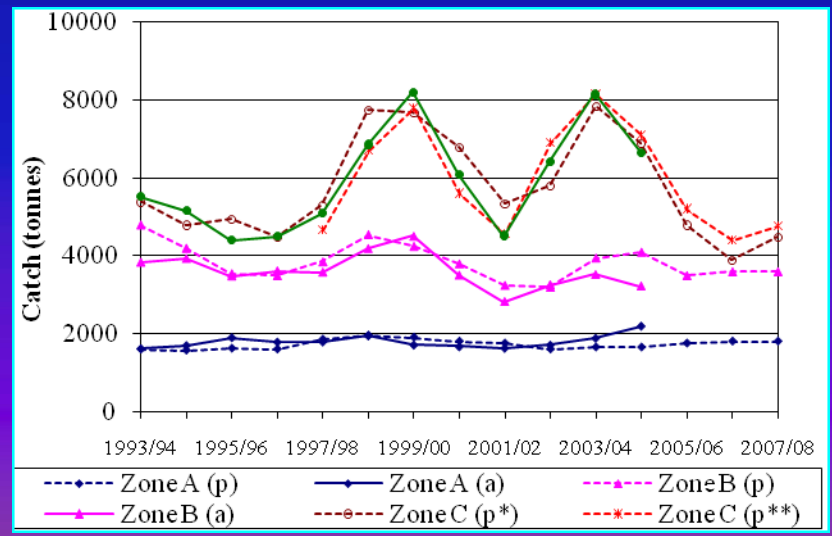
1. Boundary current dynamics, interactions and impacts on biogeochemistry and ecology

WA : Link between Leeuwin Current and rock lobster recruitment

Source: WA Dept Fisheries

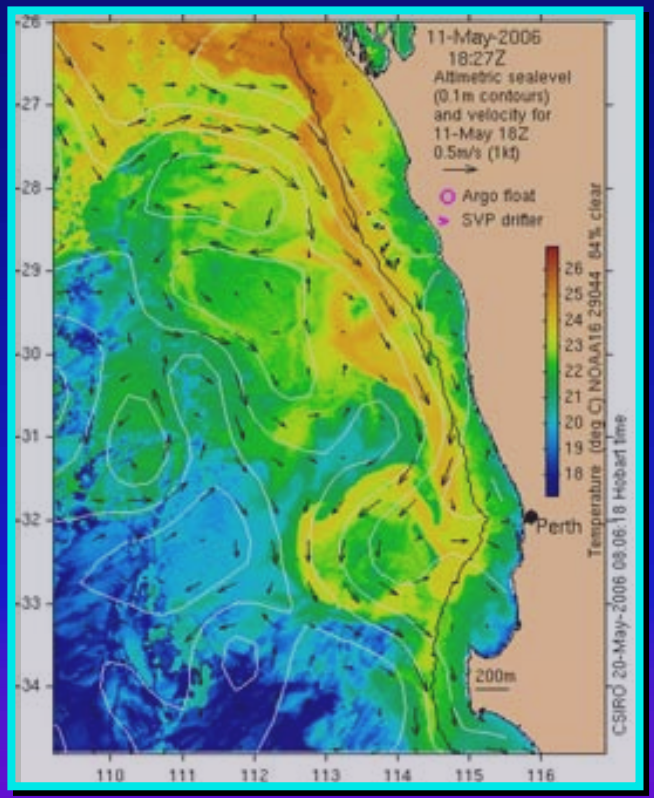


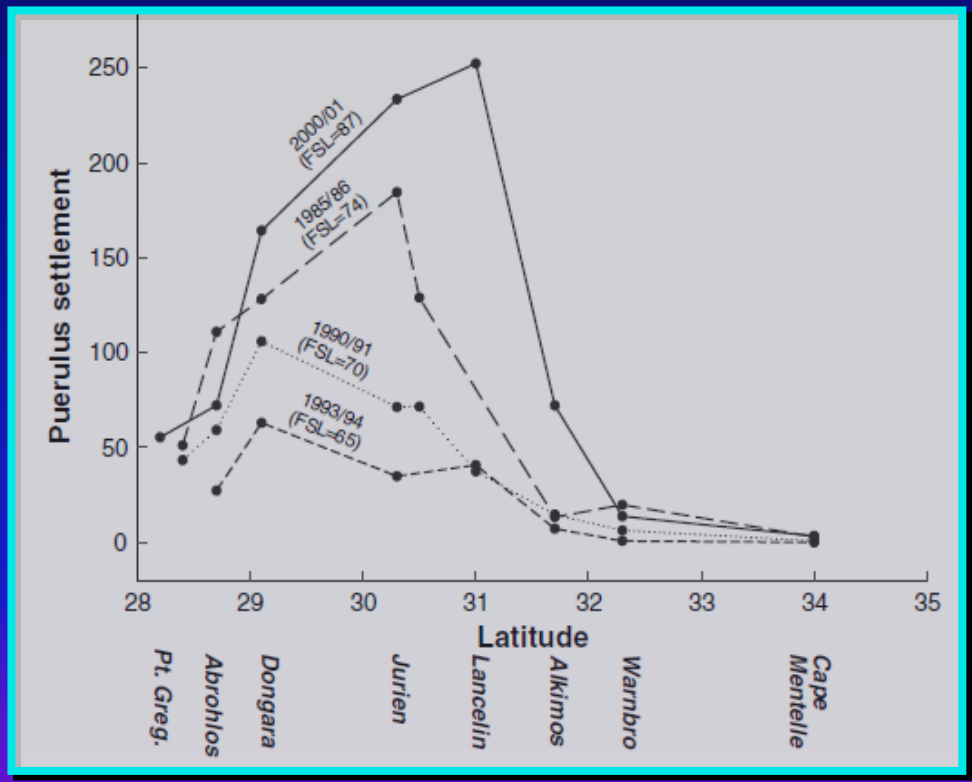




1.Boundary current dynamics, interactions and impacts on biogeochemistry and ecology

The strength of the Leeuwin Current is correlated with the level of puerulus (post-larval stage) settlement in the western rock lobster (*Panulirus cygnus*)





From Caputi 2008

Observation and modeling needs:

- Satellite observations (color, SST, and SSH in particular).
- Regional eddy resolving physical models (1/10 degree or less), i.e., the Bluelink ocean model.
- Coastal observatories with extended offshore capabilities (i.e., IMOS).

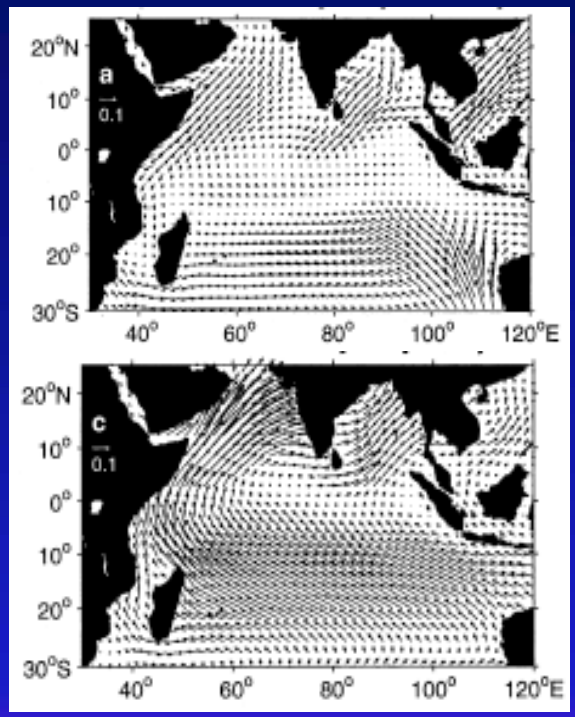
Six Major Themes Identified:

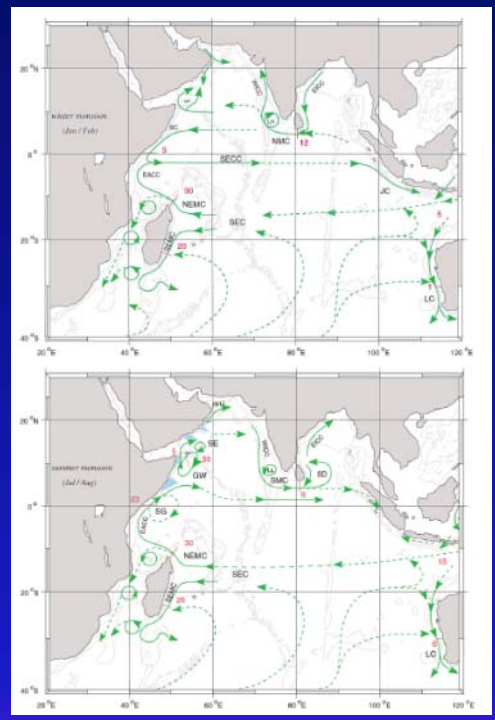
2. Dynamic variability of the equatorial zone, southern tropics and Indonesian Throughflow and their impacts on ecological processes and biogeochemical cycles

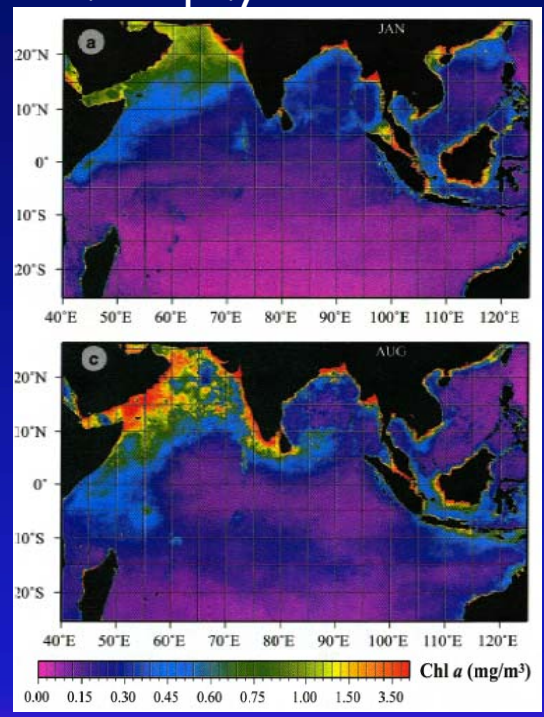
Winds | Circulation | Chlorophyll

Jan/Feb

Jul/Aug







From Schott and McCreary, 2001

From Wiggert et al. 2006

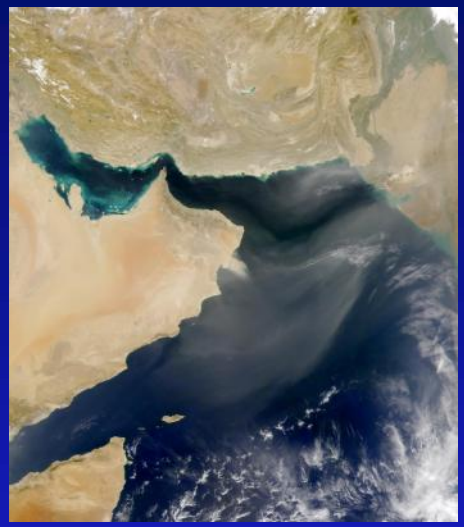
Better characterize and understand the many unique aspects of IO equatorial circulation and the ecological and biogeochemical responses to physical forcing. This includes responses to phenomena like the MJO, IOD and Wyrtki Jet, and also the ecological and biogeochemical impacts of the ITF.

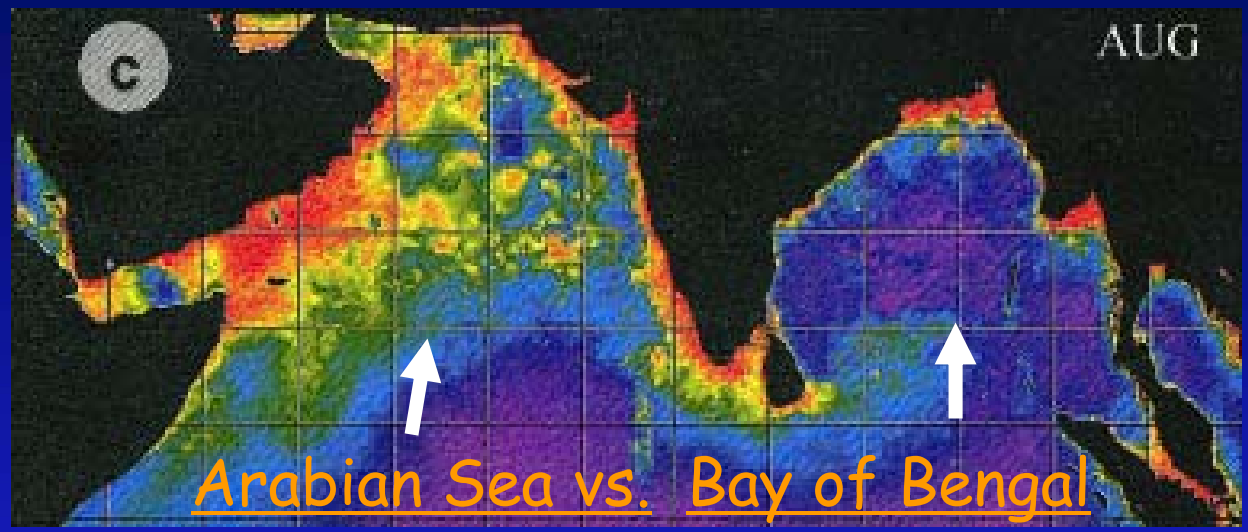
Observation and modeling needs:

- Satellite observations (color, SST, and SSH) and retrospective studies.
- Basin-wide physical models that have high resolution in equatorial waters with coupled biogeochemical models.
- Open ocean moorings (IndOOS) and ARGO floats with biogeochemical sensors, biogeochemical and ecological studies on mooring support cruises.

Six Major Themes Identified:

3. Physical, biogeochemical and ecological contrasts between the Arabian Sea and the Bay of Bengal





The Arabian Sea and Bay of Bengal are similar in size, latitude and both have northern land boundaries. However, they have very different surface forcing, dust deposition and freshwater fluxes and therefore biological responses. Both the Arabian Sea and the Bay of Bengal have OMZs. As a result, the Arabian Sea is a globally important zone of open-ocean denitrification but the Bay of Bengal remains poised just above the denitrification threshold.

Observation and modeling needs:

- Comparative satellite observational studies between the AS and the BoB (color, SST, and SSH).
- Basin-wide physical models with coupled biogeochemical models that can simulate oxygen.
- Open ocean time-series stations and moorings in the Arabian Sea and the Bay of Bengal.
- ARGO floats with biogeochemical sensors.

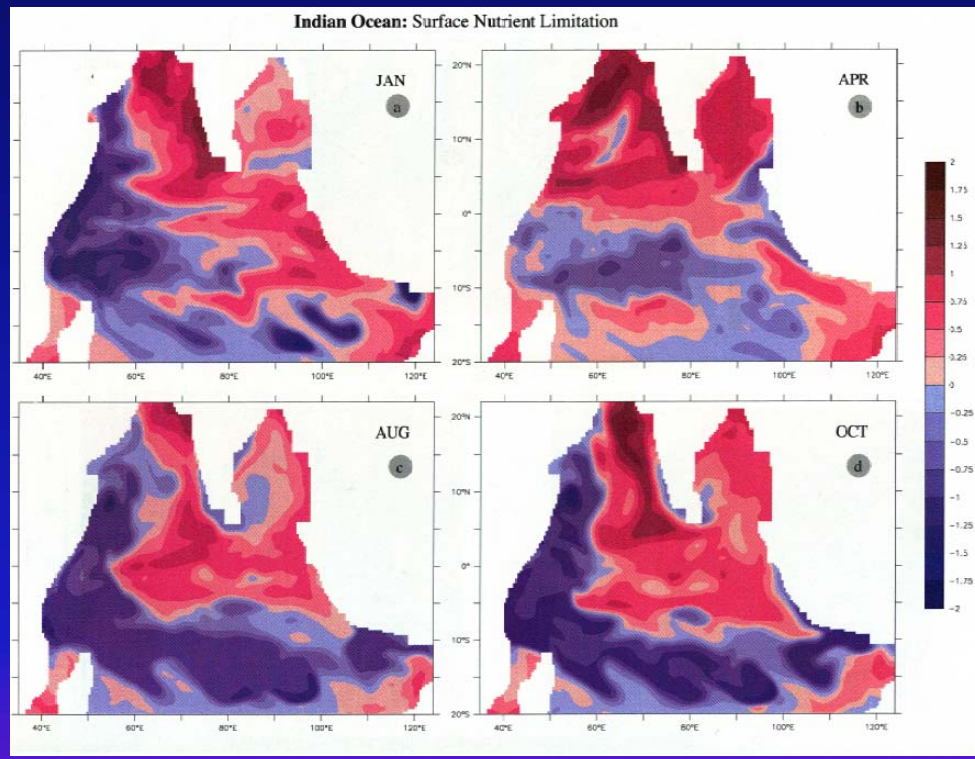
Six Major Themes Identified:

4. Controls and fate of phytoplankton and benthic production in the Indian Ocean

Some major questions and hypotheses that emerged from previous studies (e.g. JGOFS) still remain to be tested.

Do low iron levels in surface waters limit phytoplankton production during the SWM in the Arabian Sea?
What is the potential role of mesozooplankton grazing in limiting phytoplankton production during the SWM in the Arabian Sea?

The relative influence of grazing and Fe limitation needs to be explored with *in situ* experiments over the entire region



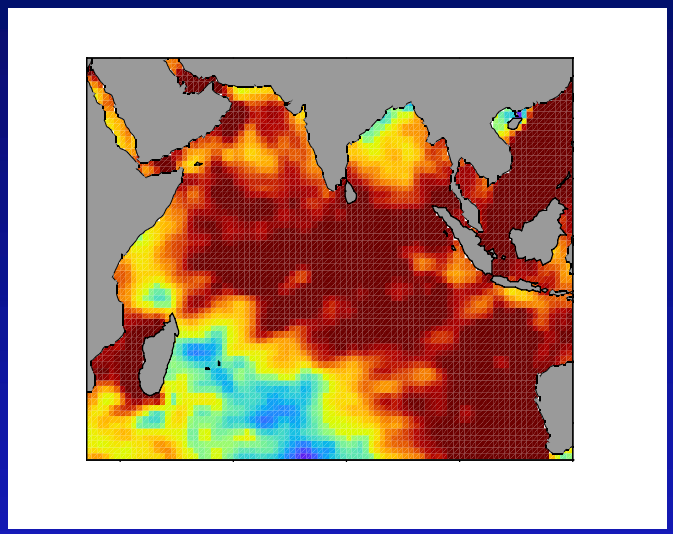
From Wiggert et al. (2006)

Observation and modeling needs:

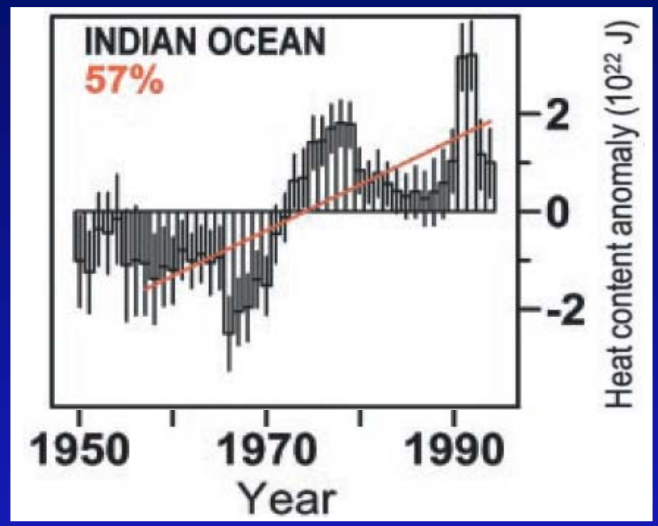
- Basin-wide satellite observational studies (color, SST, and SSH).
- Basin-wide physical models with coupled biogeochemical models & multiple limiting nutrients.
- Coastal and open ocean observatories.
- Ship-based process studies and experimental manipulations.

Six Major Themes Identified:

5. Climate and anthropogenic impacts on the Indian Ocean and its marginal seas



From Meyers et al. 2005 IOP Report



From Levitus et al. 2000

The IO is warming rapidly and may provide a preview of how climate change will affect the ecology and biogeochemistry of other ocean basins. The IO accounts for ~1/5 of the global oceanic uptake of atmospheric CO_2, but large uncertainties remain. High river loading, along with large and increasing populations and rapid economic growth of surrounding countries, make the coastal environments in the IO particularly vulnerable to anthropogenic perturbations.

Observation and modeling needs:

- Retrospective satellite observational studies (color and SST in particular).
- Basin-wide physical models with coupled biogeochemical models and carbon cycling.
- Watershed models that can provide estimates of freshwater and nutrient loading.
- Long-term coastal and open ocean monitoring.

Six Major Themes Identified:

6. Role of higher trophic levels in ecological processes and biogeochemical cycles

FORV Sagar Sampada-Fishing

Myctophids

The Arabian Sea has one of the largest pelagic fish stocks in the world (myctophids). Biomass estimates need to be confirmed and time-space variability quantified.

Evidence suggests that tuna migrations in equatorial waters are strongly influenced by the IOD.

Many coastal fisheries have been impacted/depleted due to anthropogenic effects.

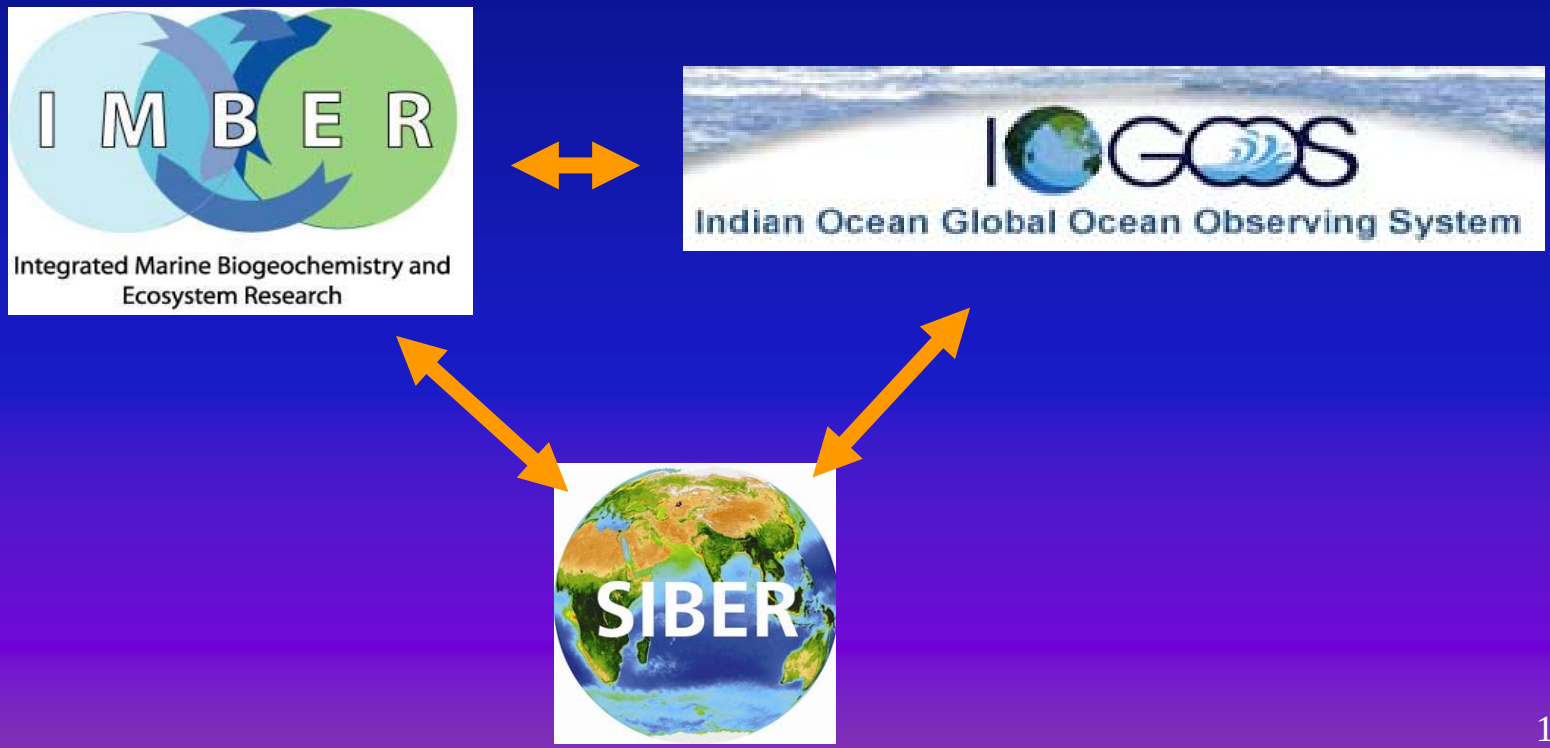
Studies on how higher trophic levels influence lower trophic levels and biogeochemical cycles

Observation and modeling needs:

- Satellite observational studies (color and SST).
- Physical models with coupled biogeochemical models, zooplankton and offline IBMs of fish/behavior.
- Stock assessment models.
- Physiological and behavioral studies.

Programmatic Considerations:

- IMBER and IOGOOS provide logical international programmatic homes for SIBER
- SIBER will emerge as a major regional program under IMBER
- SIBER has also established strong linkages with IOGOOS
- These linkages will also promote links between IMBER and IOGOOS



Integrated Marine Biogeochemistry and Ecosystem Research

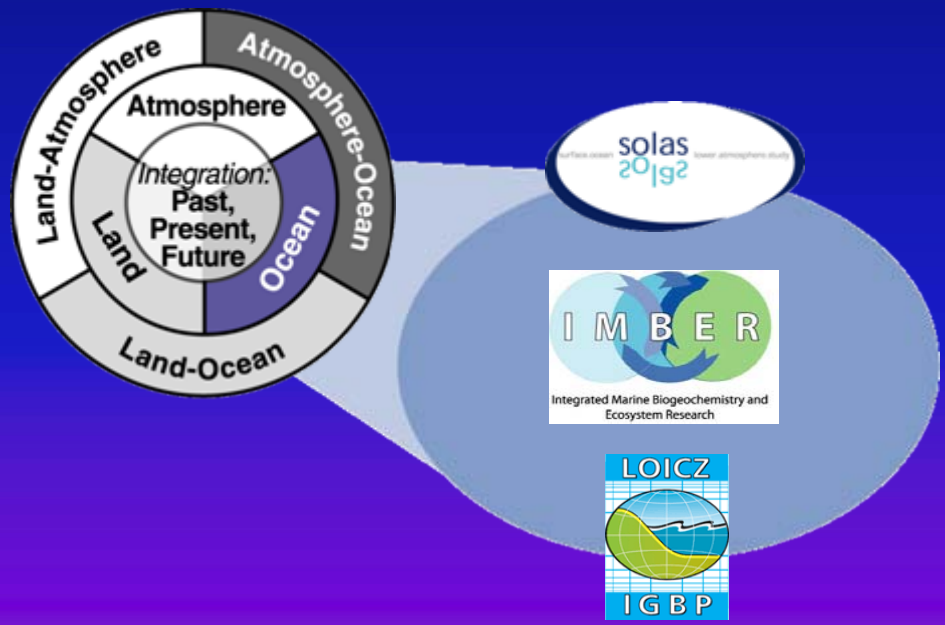
Programmatic Considerations:

What Is IMBER?

IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) is:

- A new IGBP-SCOR project focusing on ocean biogeochemical cycles and ecosystems and their interactions.
- IMBER is building on the successes of the now-complete JGOFS and the nearly complete GLOBEC project.
- The IMBER vision is *to provide a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society.*
- **The SIBER vision is synonymous with that of IMBER but is focused regionally on the Indian Ocean.**

Ocean Projects in IGBP II post 2009



Programmatic Considerations:

What Is GOOS/IOGOOS?

GOOS (the Global Ocean Observing System) is a global system for sustained observations of the ocean comprising the oceanographic component of the Global Earth Observing System of Systems (GEOSS).

GOOS is designed to:

- Monitor, understand and predict weather and climate
- Describe and forecast the state of the ocean, including living resources
- Improve management of marine and coastal ecosystems and resources
- Mitigate damage from natural hazards and pollution
- Protect life and property on coasts and at sea
- Enable scientific research

IOGOOS (Indian Ocean Global Ocean Observing System) is a regional alliance:

It is an Association of marine operational and research agencies in the Indian Ocean region established during Indian Ocean Principals' Meeting held on November 8-9, 2001 at New Dehli to co-operate in promoting GOOS in the Indian Ocean region. IOGOOS was formally established on November 5, 2002.

We anticipate that there will be opportunities in the future to leverage IOGOOS infrastructure and other regional GOOS programs (e.g., SEAGOOS, NEARGOOS, INAGOOS, WAGOOS) and we hope that emerging new SIBER measurement programs, process studies and modeling efforts will augment and expand IOGOOS and related regional GOOS monitoring and modeling efforts in the Indian Ocean.

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Thank You